Supersonic Tunnel Association International

Ames Research Center

Subsonic Aerodynamic Testing Association

Laser Incident in the NASA Ames Unitary Plan Wind Tunnel

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Supersonic Tunnel Association International (STAI)

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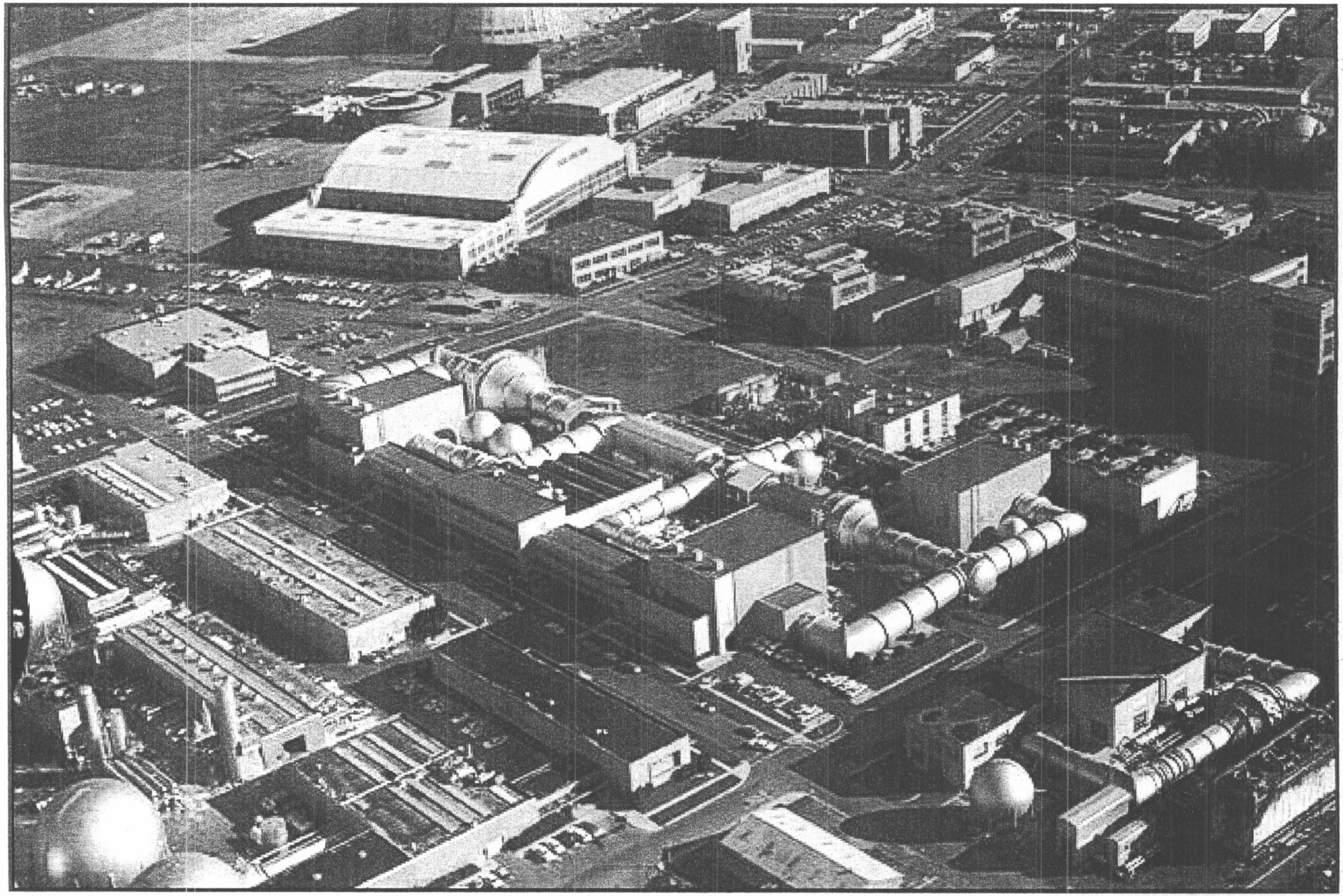
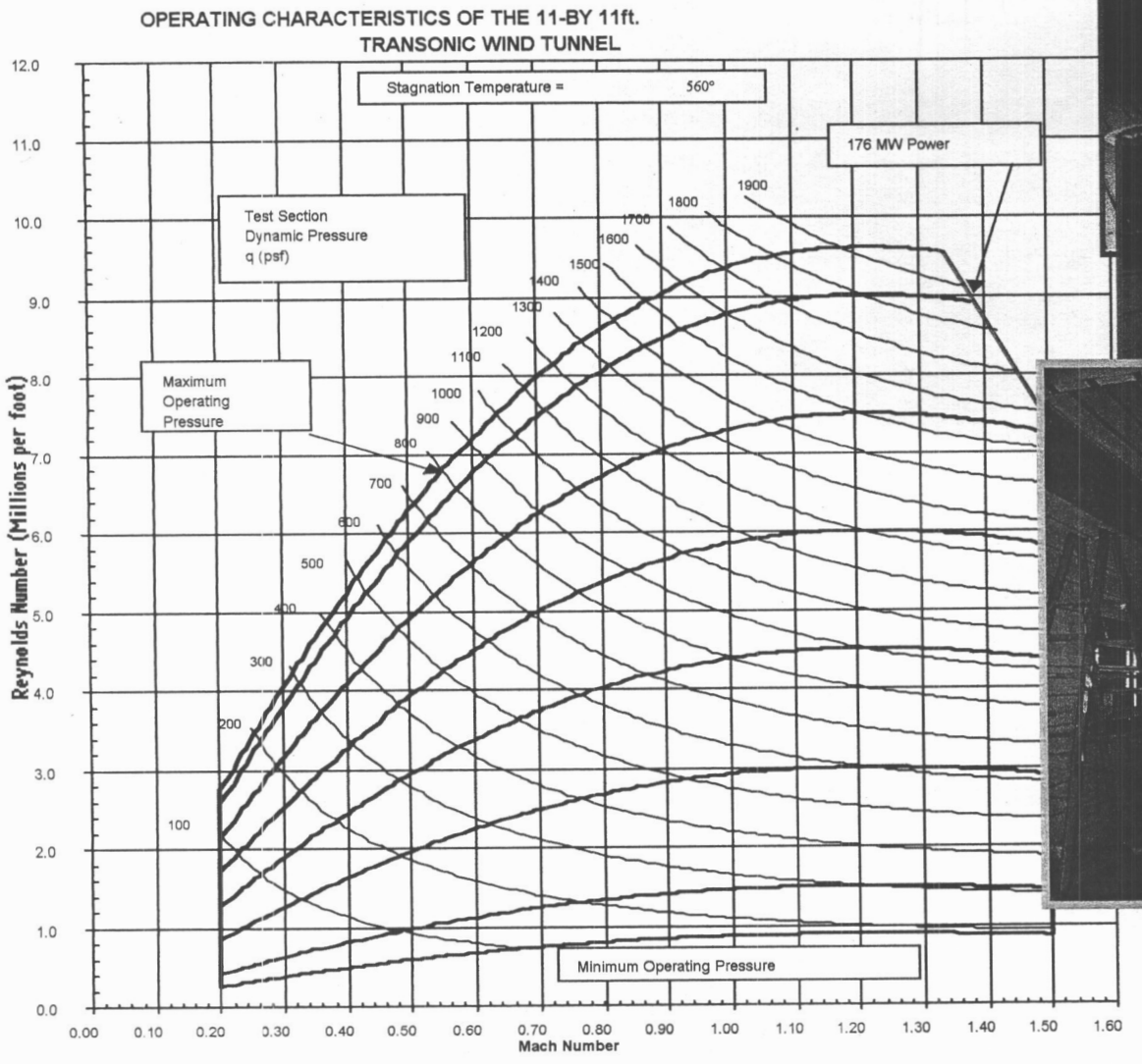
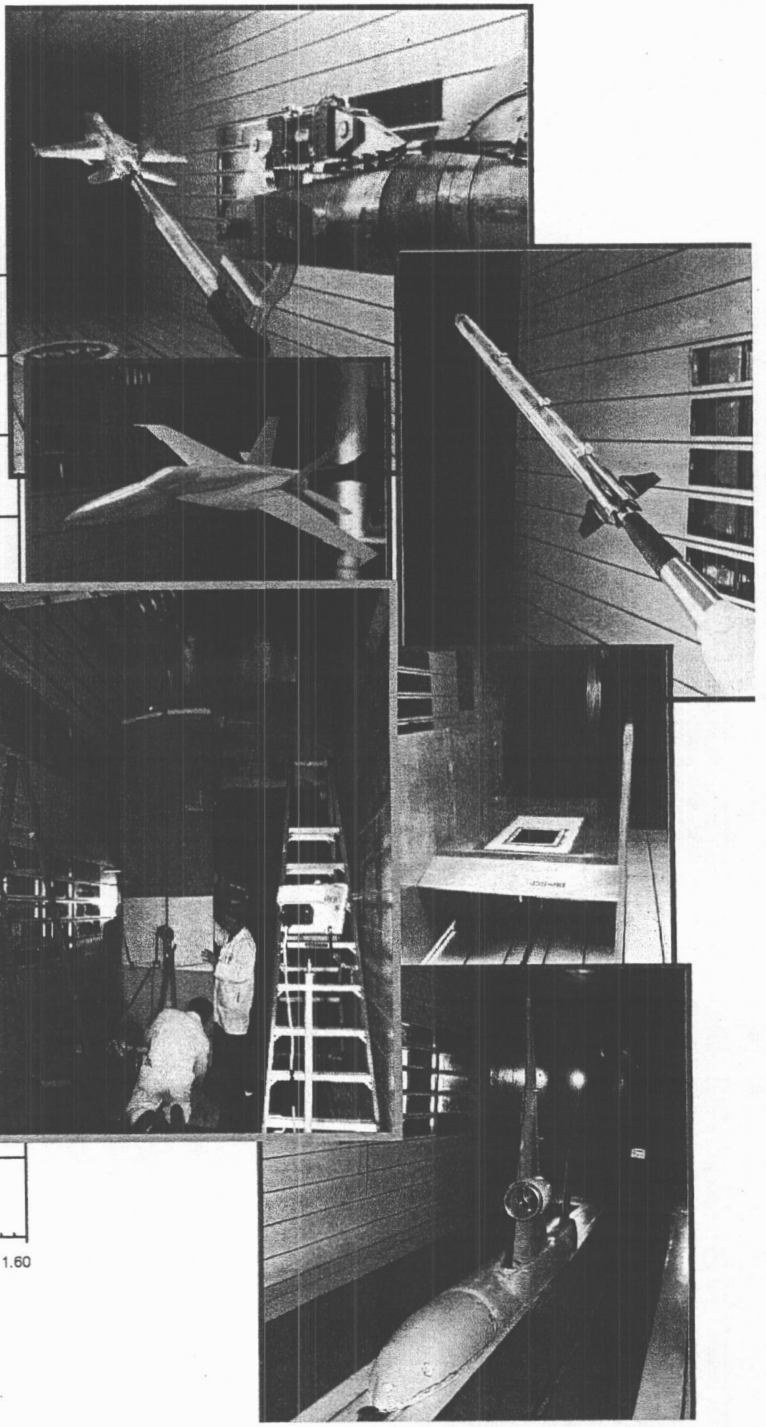
Unitary Plan Wind Tunnel (UPWT)

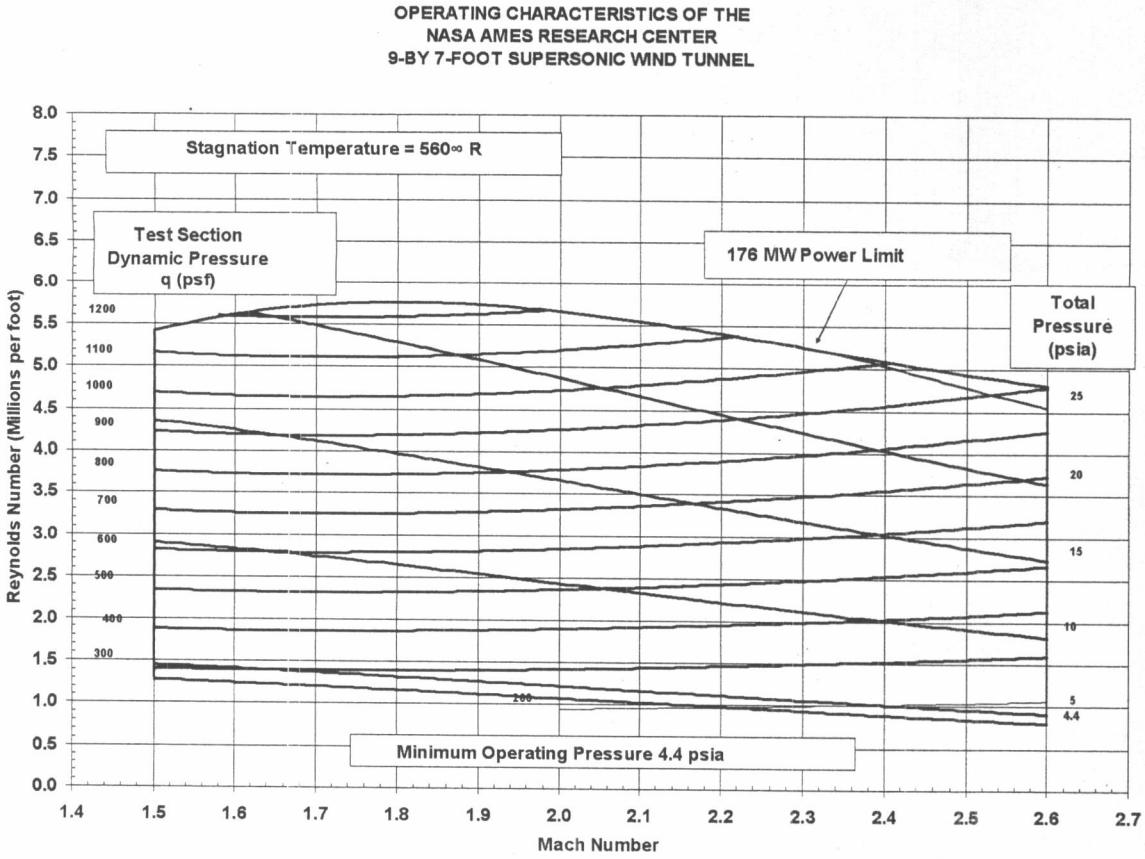


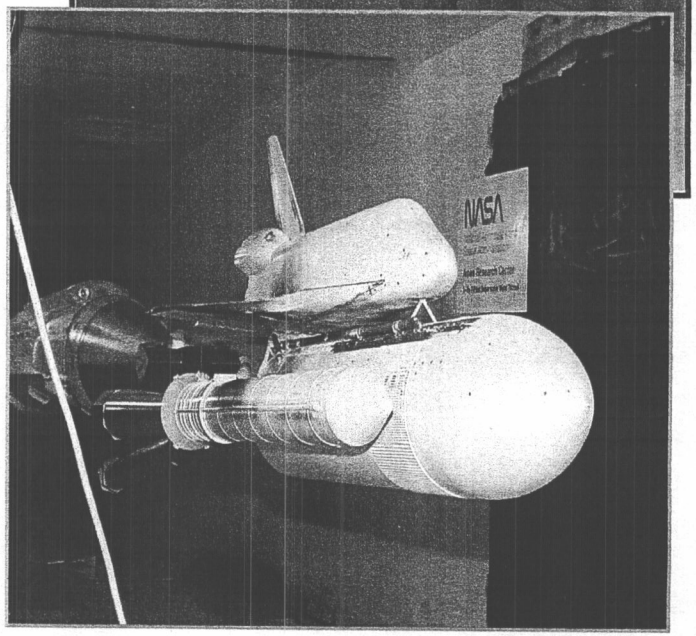
UPWT
11'x 11' Transonic Wind Tunnel



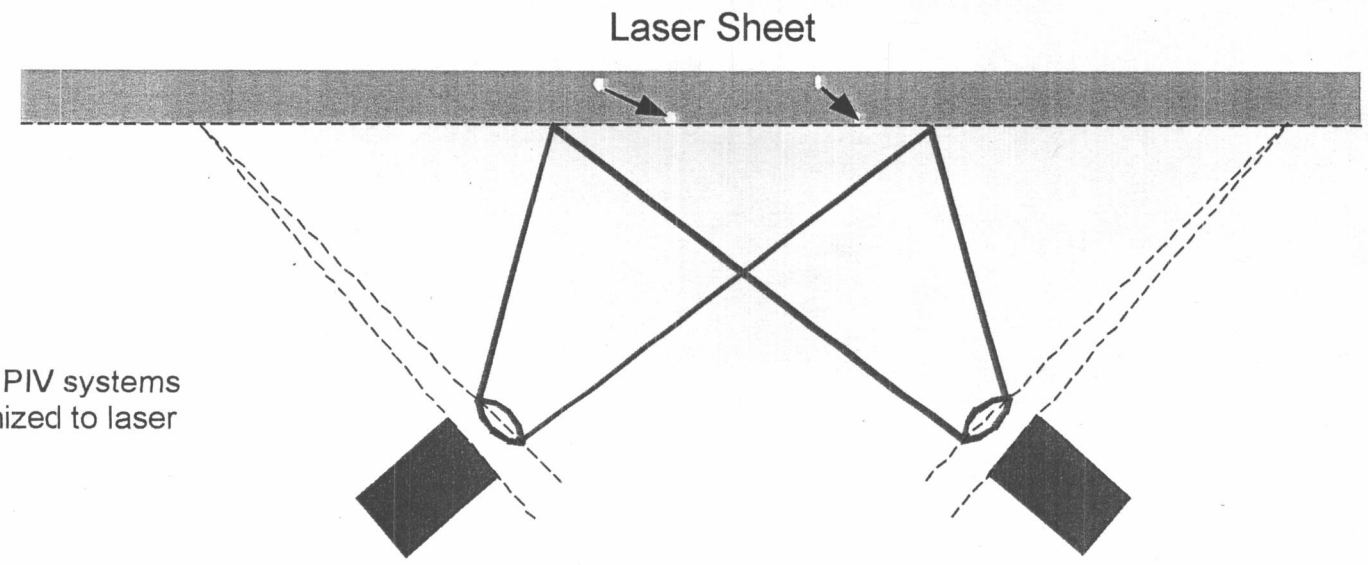


UPWT
9'x 7' Supersonic Wind Tunnel

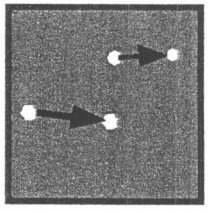




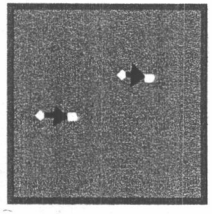
3D Particle Image Velocimetry (PIV)



Two, 2D PIV systems synchronized to laser

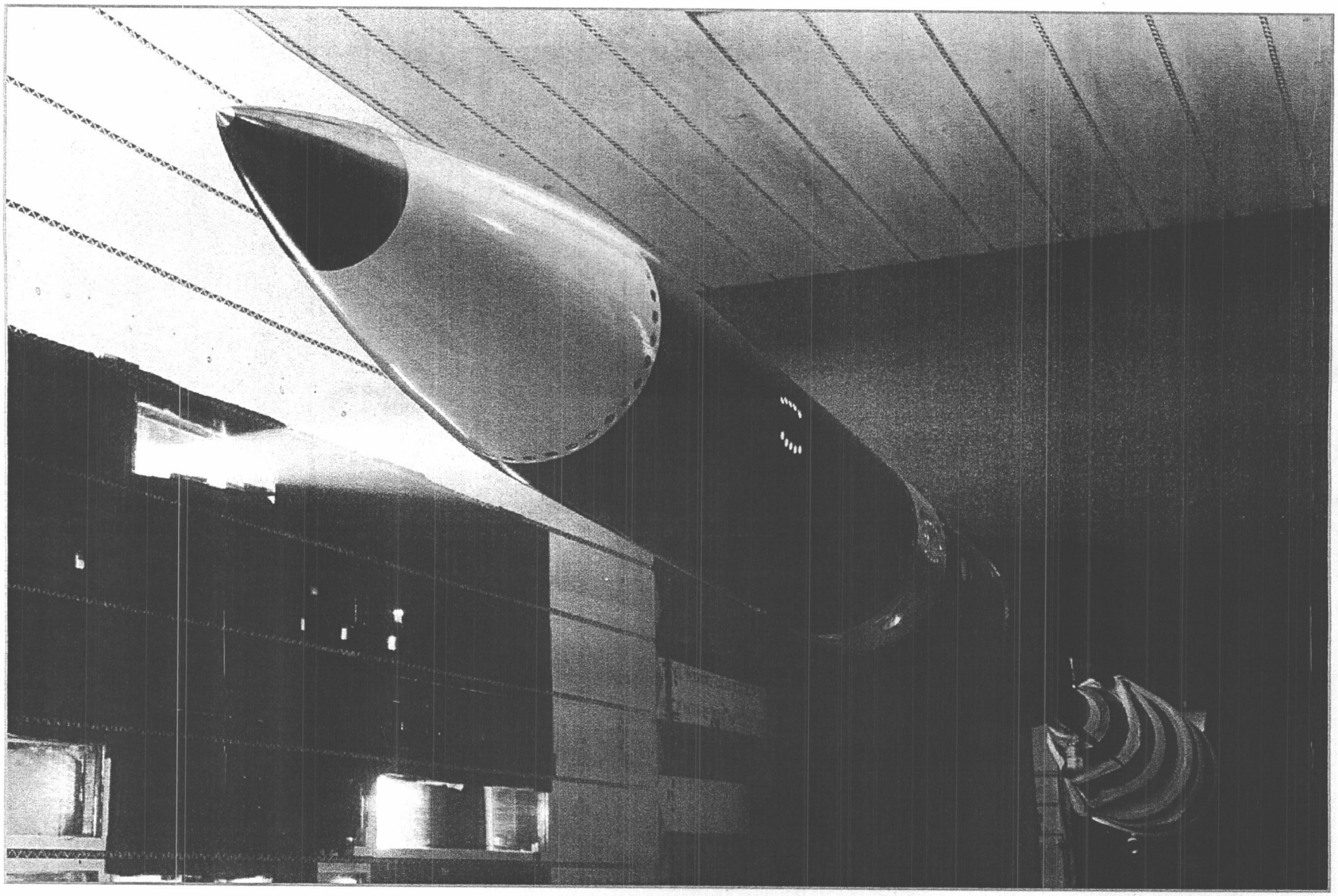


3D PIV Camera 1 View

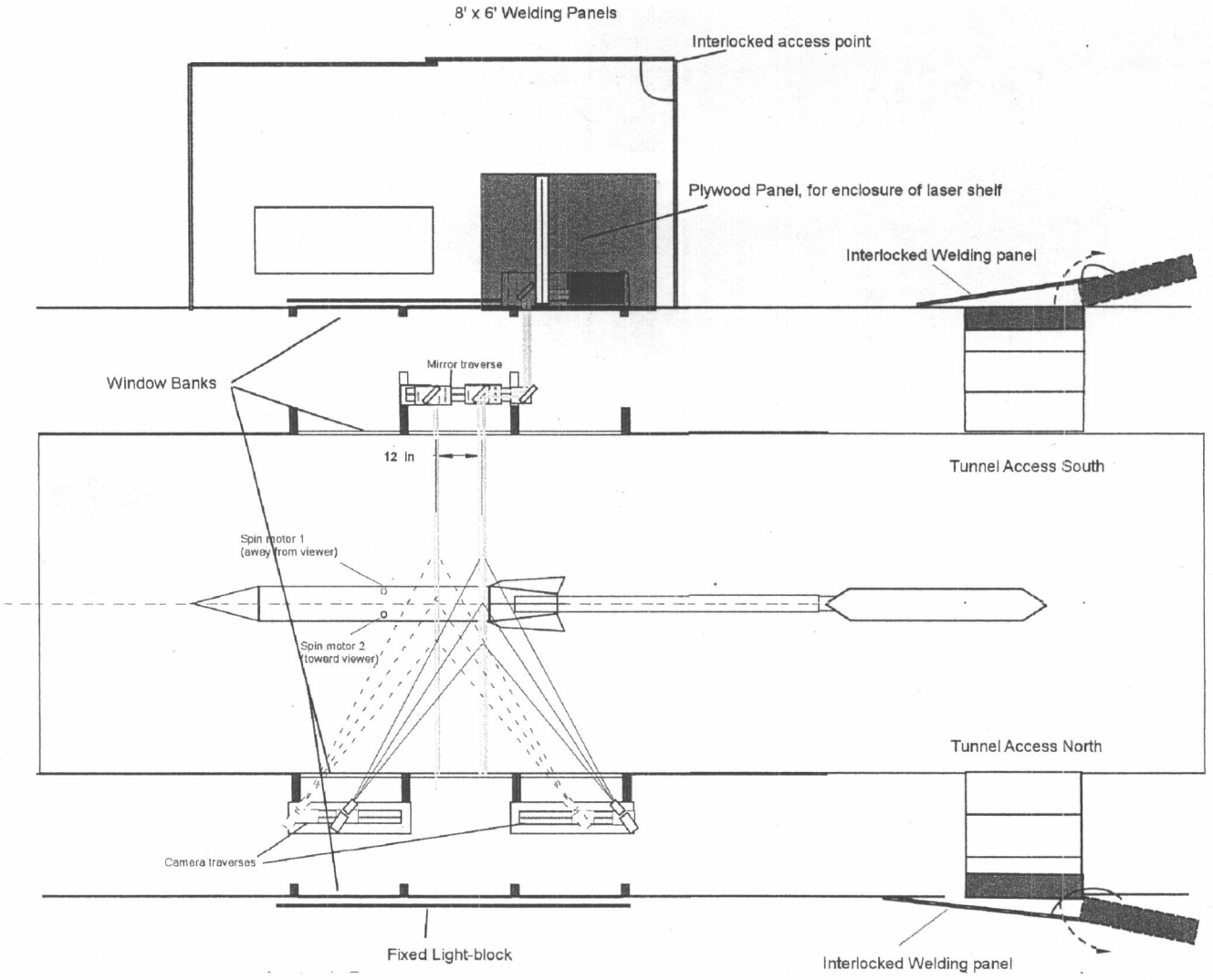


3D PIV Camera 2 View

PIV System in 11' x 11' Transonic Test Section

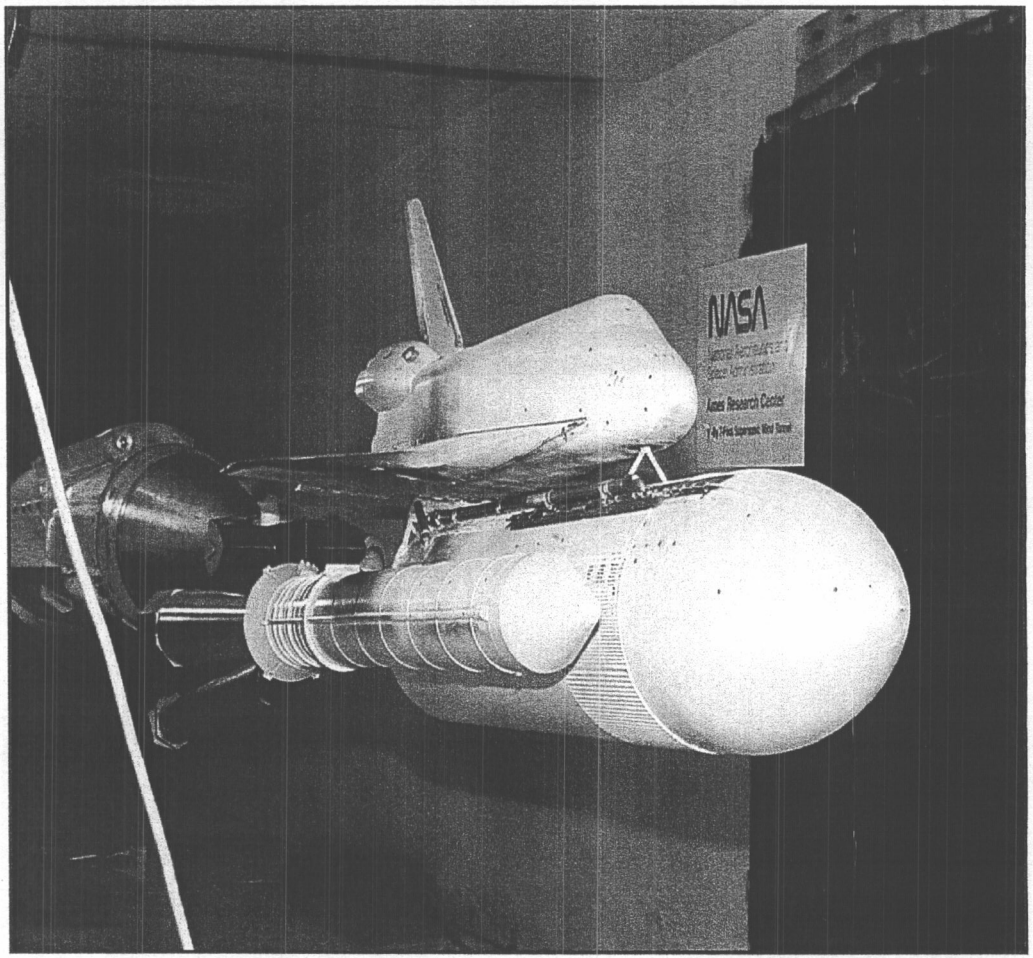


PIV installation in 11' x 11' TWT

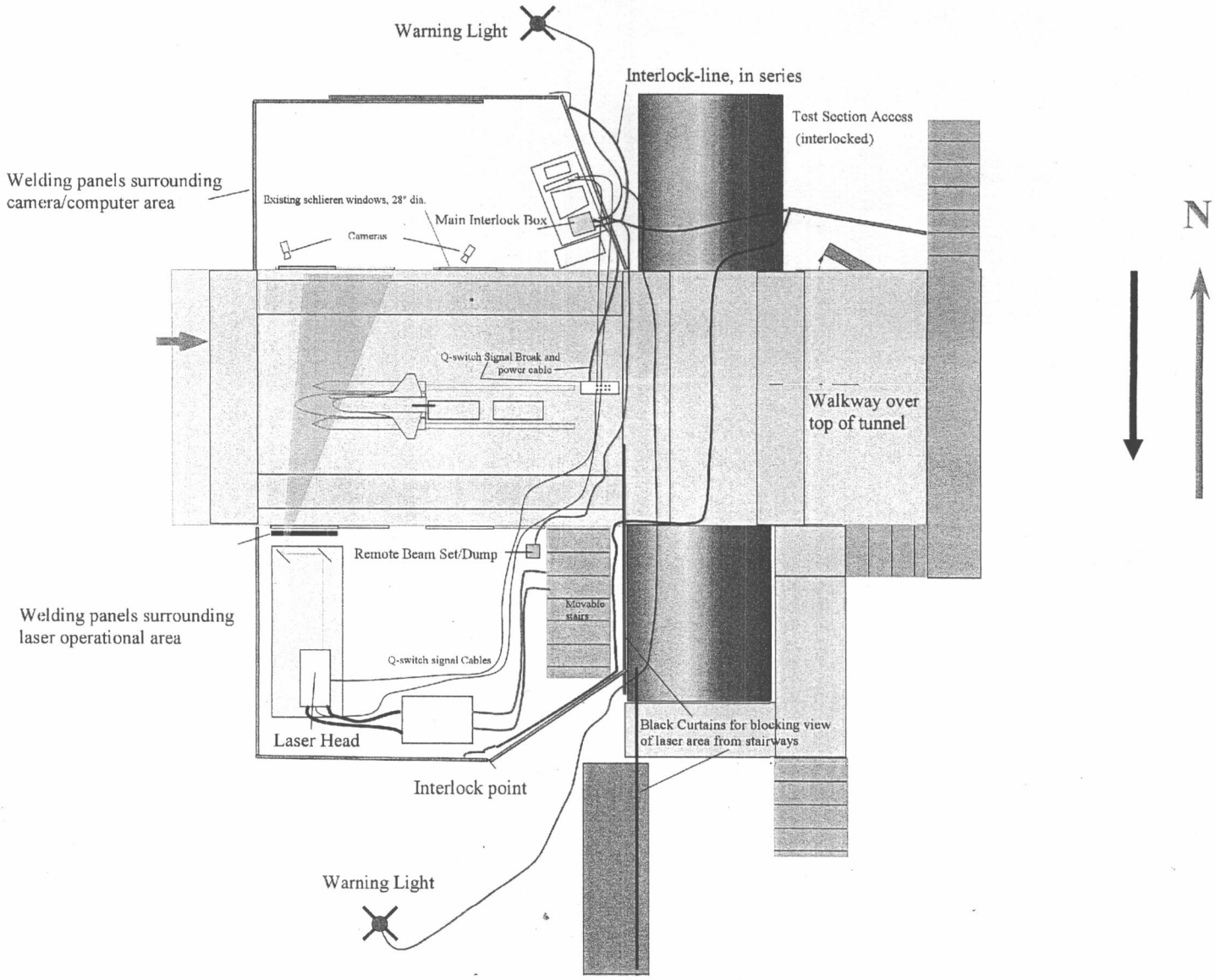


3% Space Shuttle Ascent Configuration Test in UPWT 9' x 7' Test Section

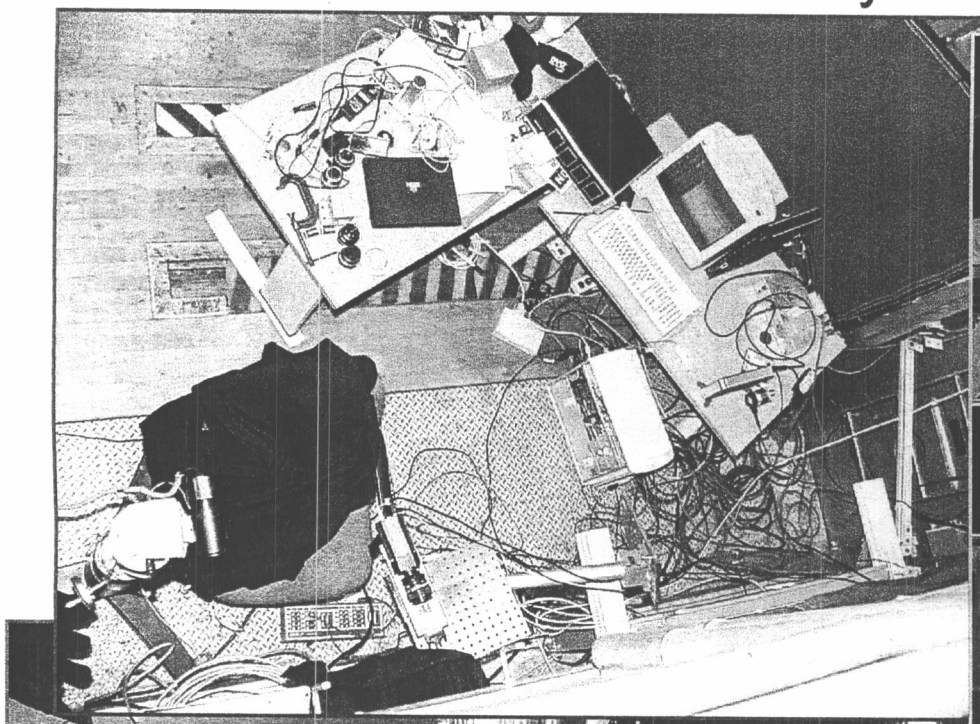
- As part of the Space Shuttle Program, Return to Flight effort a 3% Space Shuttle Model was being tested in the Ames Unitary Wind Tunnel 9x7 Test Section.
  - A Particle Imaging Velocimetry (PIV) system was utilized to obtain a database for validation of Computational Fluid Dynamics (CFD) codes used to predict the trajectories of debris shed during launch.
  - *The PIV system utilized a Class IV laser to illuminate particles in the flow field.*

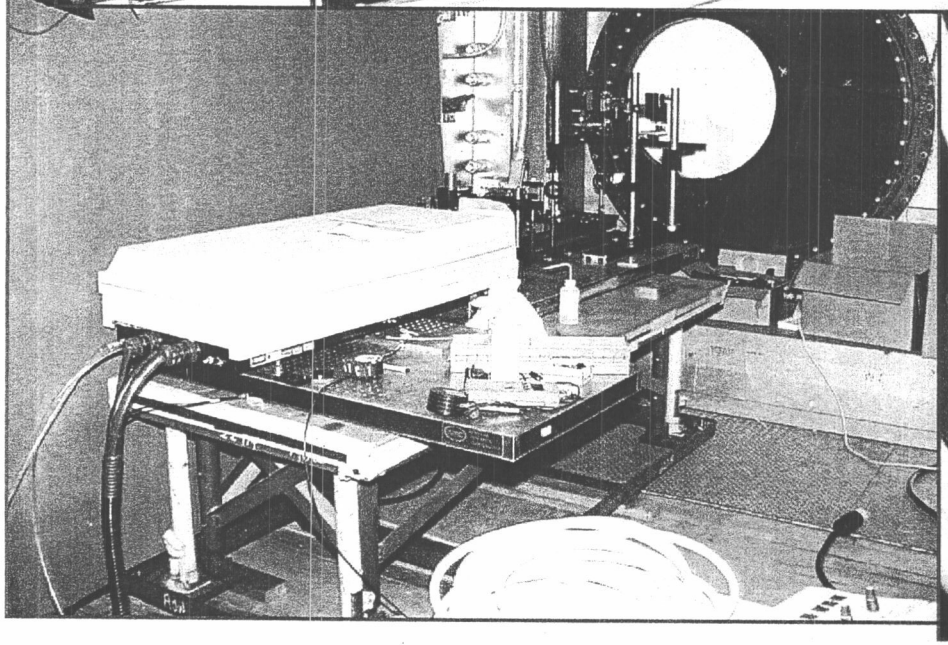


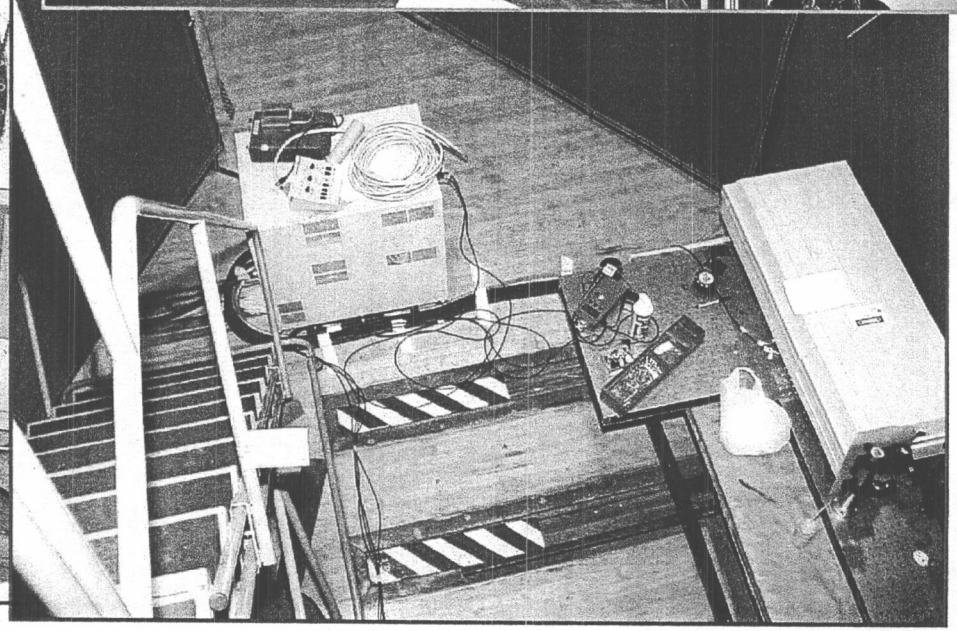
PIV installation in 9' x 7' SWT



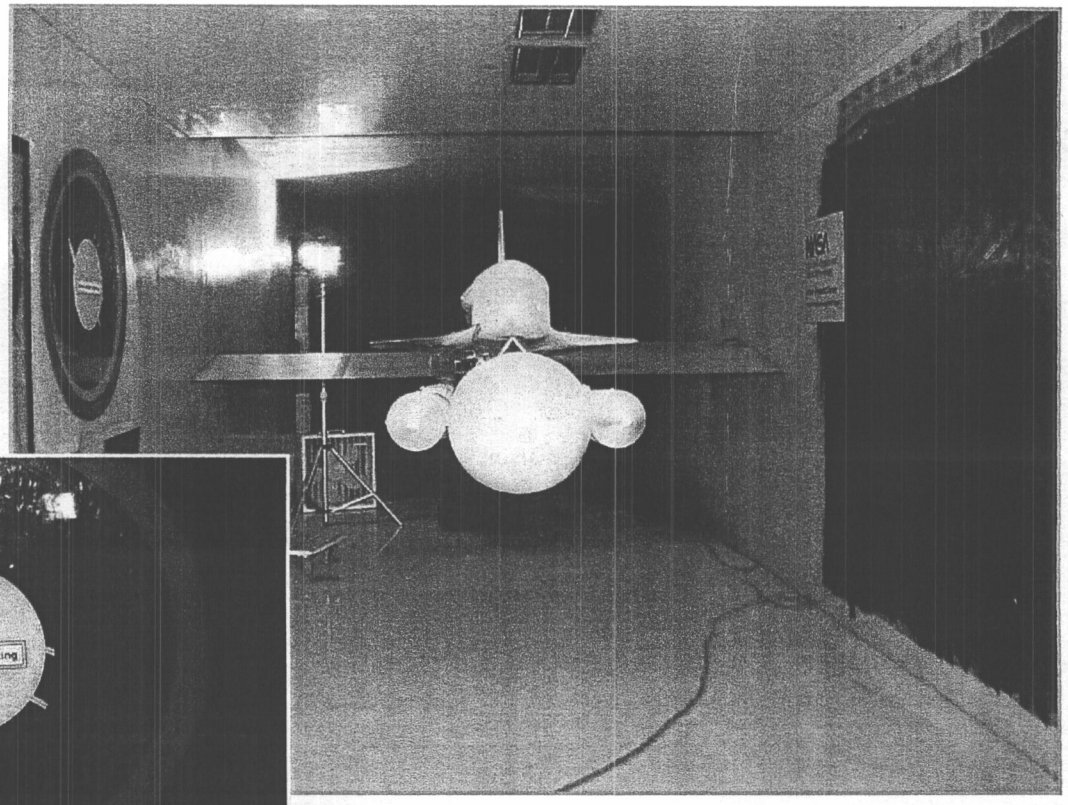
PIV Laser System in 9' x 7' SWT

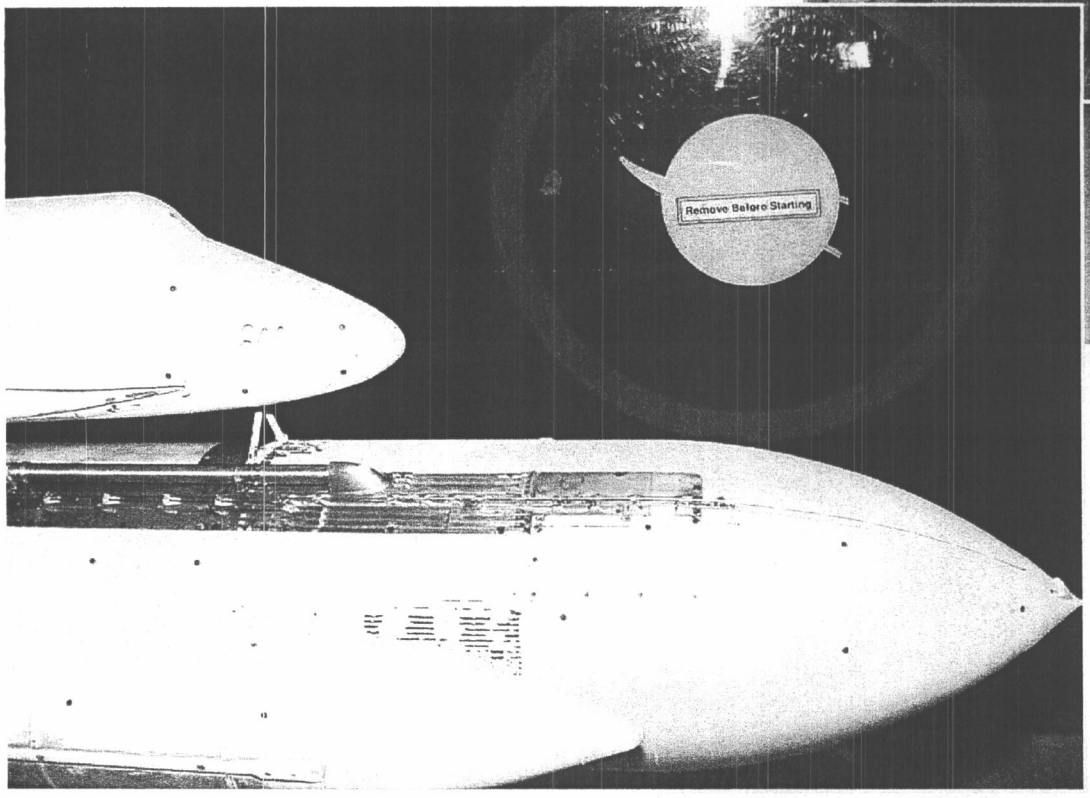




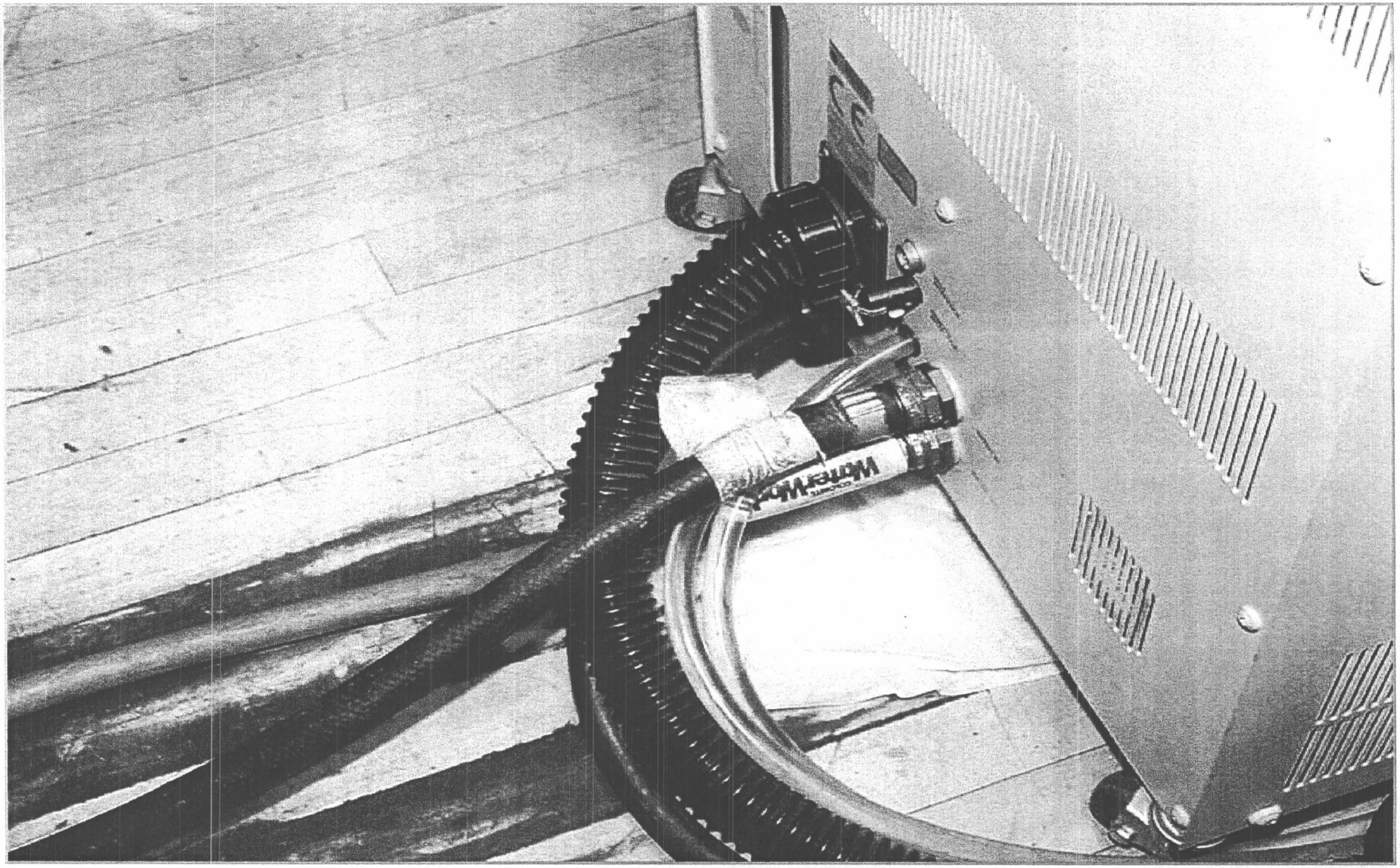


PIV Laser System Access Window

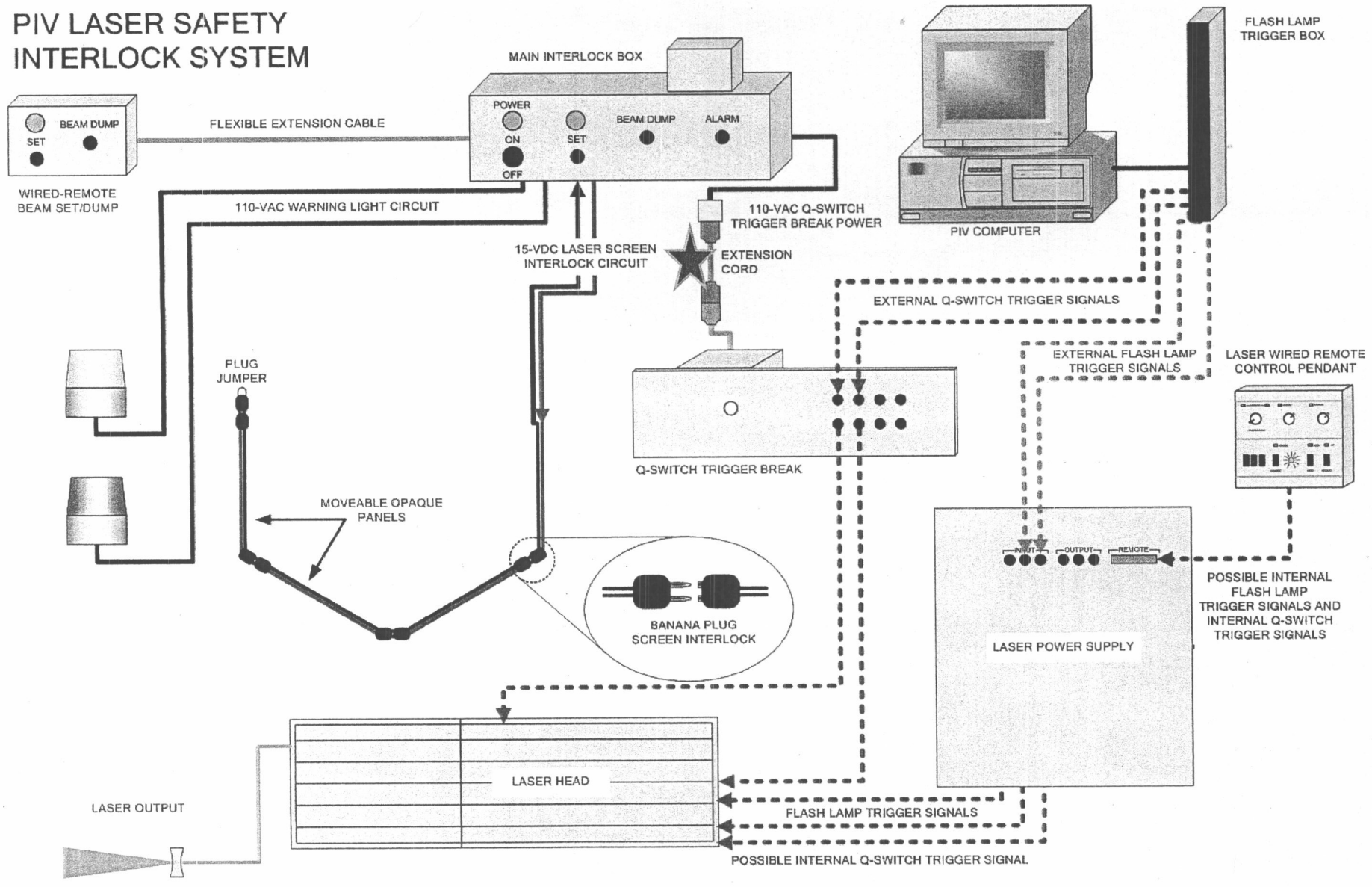




Cooling Water Leak at Rear of Power Supply

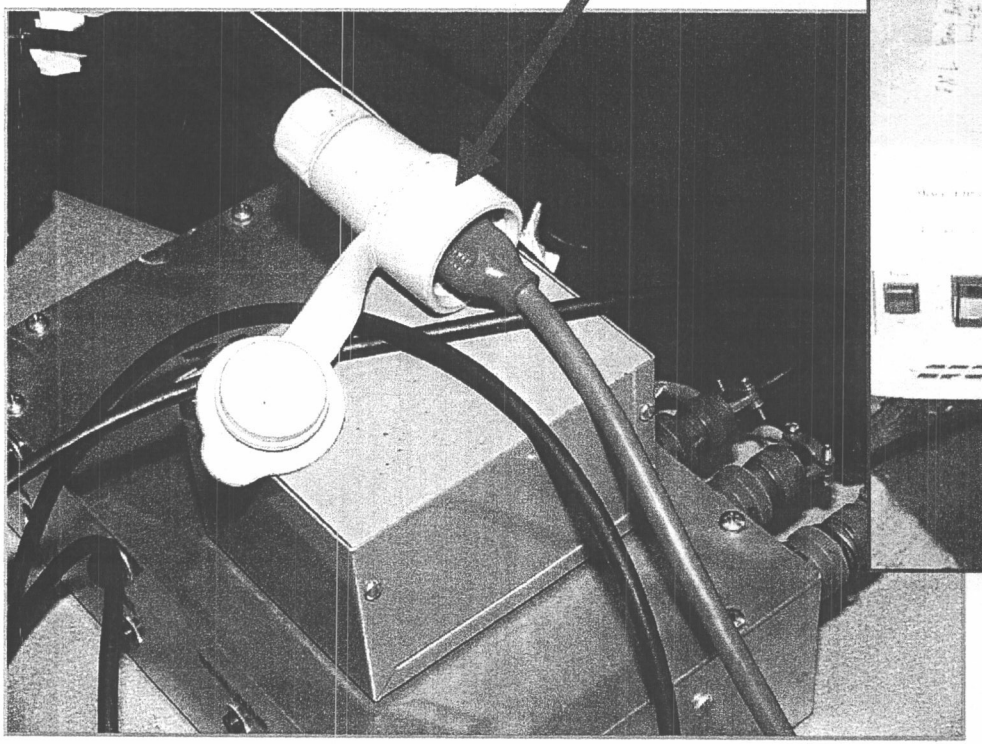


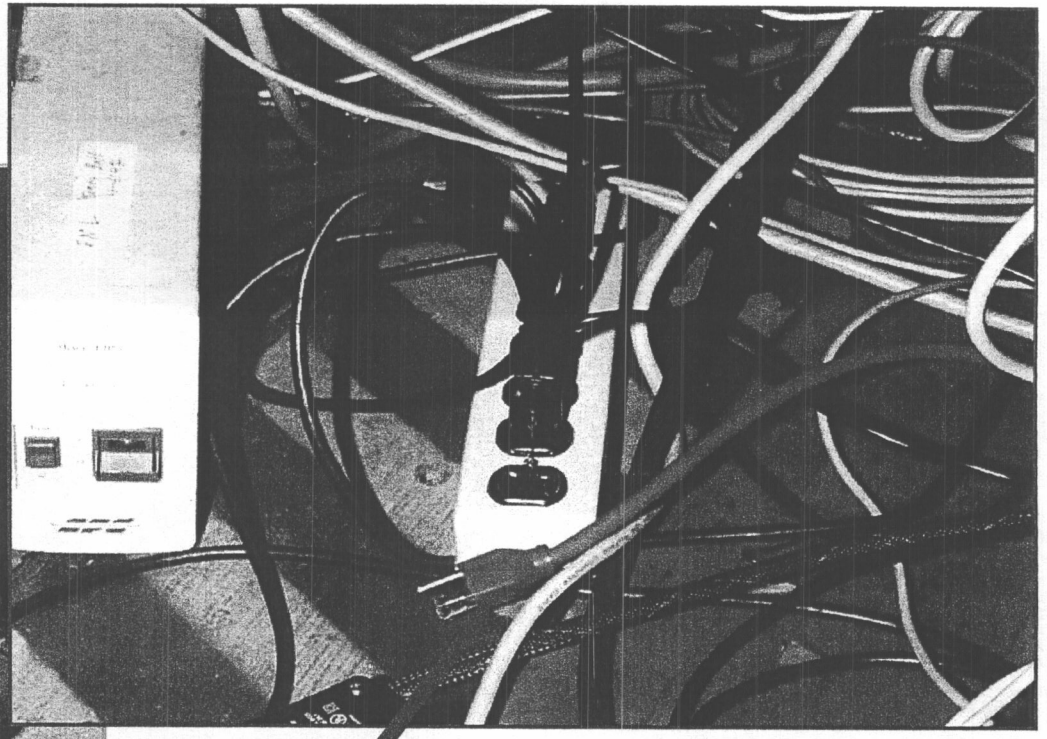
PIV Laser Safety Interlock System



Safety Interlock Cable

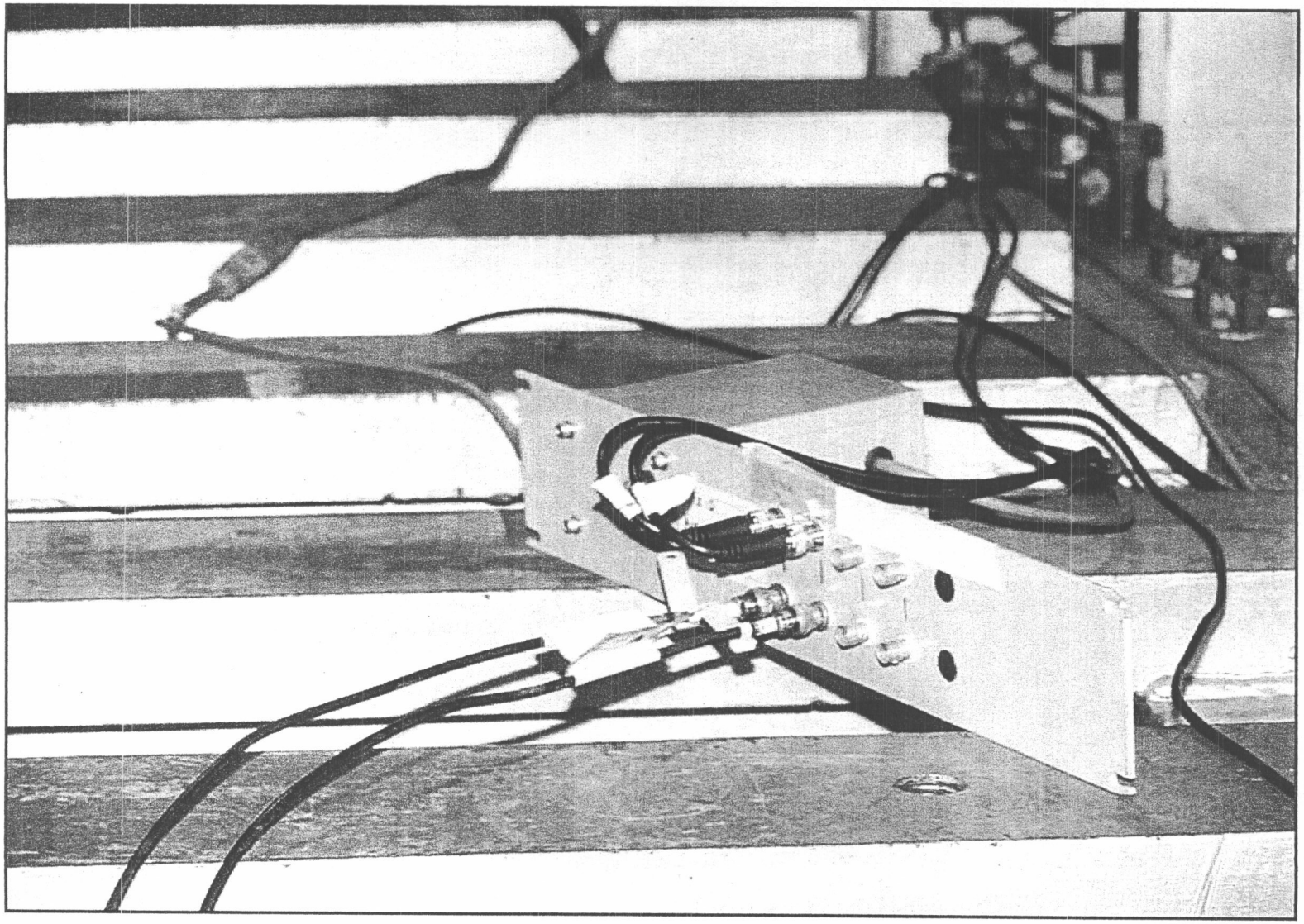
Correct Connection - End of extension chord plugged into the interlock box.





Incorrect Connection - End of extension chord plugged into outlet by mistake and therefore bypasses safety interlock system.

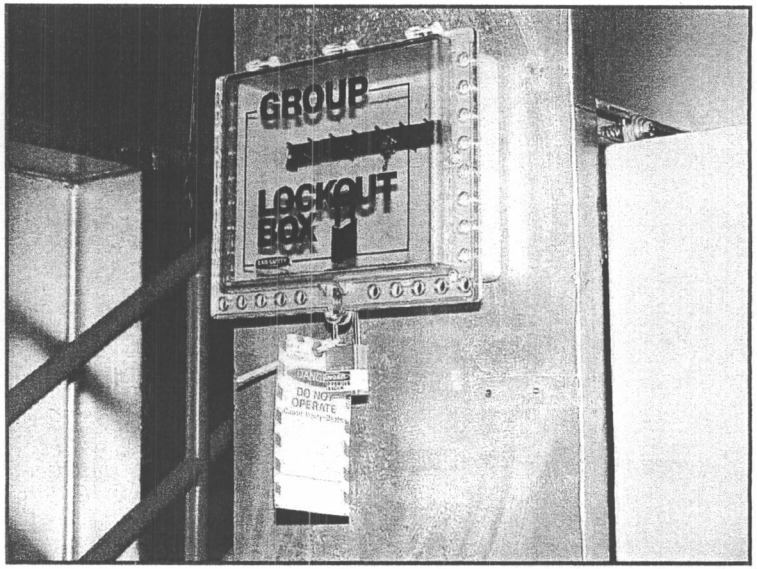
Q-Switch located on top of 9' x 7' Test Section



Investigation Findings and Recommendations

Causes

- Interlock switch bypassed
- Test personnel not in control of safety
- Inadequate physical barriers
- Schedule pressures
  - > 12 hour personnel shifts
  - Rushed redeployment of laser system
  - Change Request Review bypassed

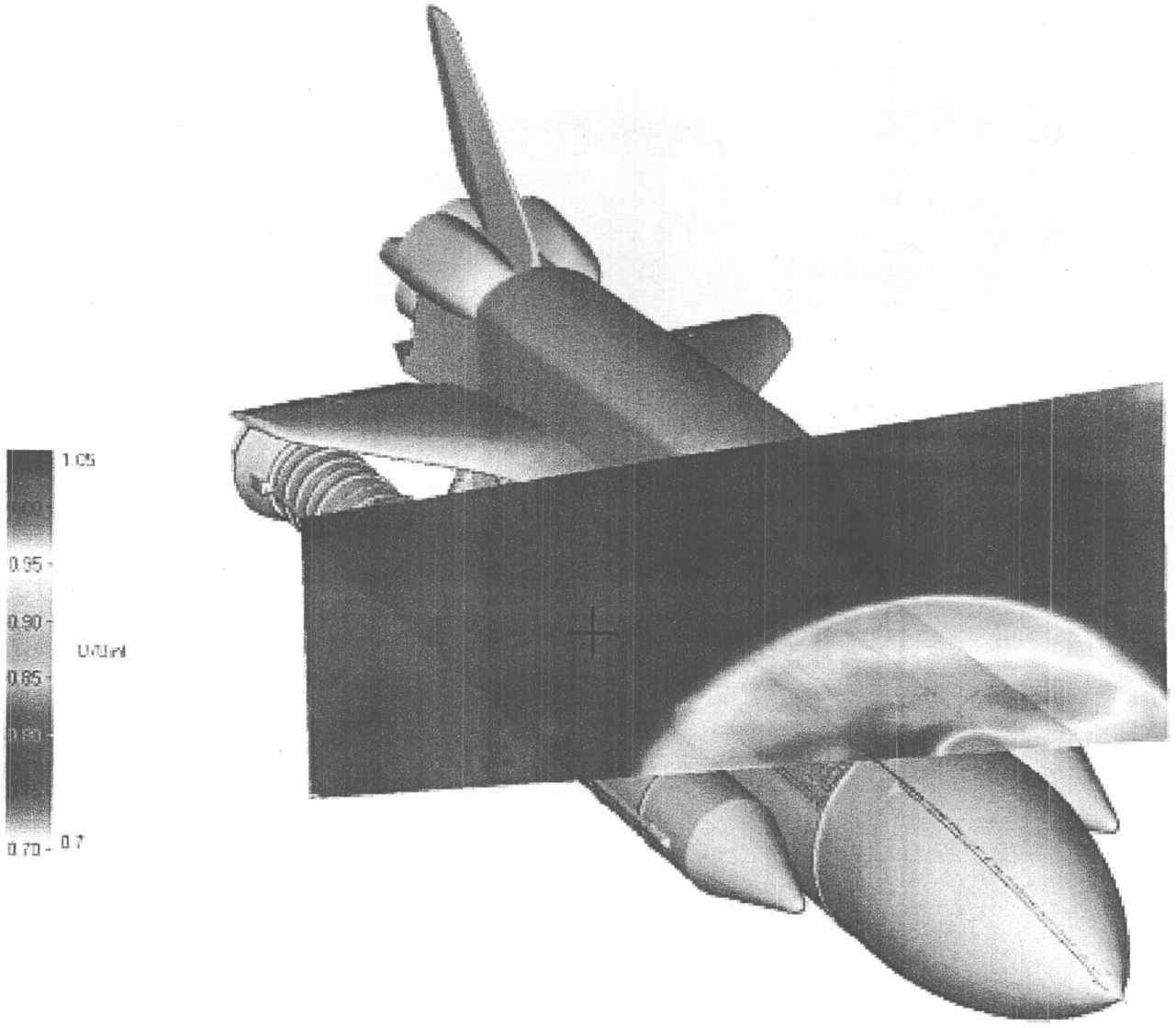


Fixes

- Modified interlock system with unique electrical connectors
- Lock Out Tag Out (LOTO) required for tunnel access when PIV system installed in facility.
  - Power supply locked out
- Physical beam block at laser head and window.
- Entire test team adopt 12 hour work rule
- Redefine what a configuration change is
- Installed emergency stop switches

PIV Results for 3% Space Shuttle Model in UPWT 9'x7'

Normalized axial velocity @ Mach number = 2.5



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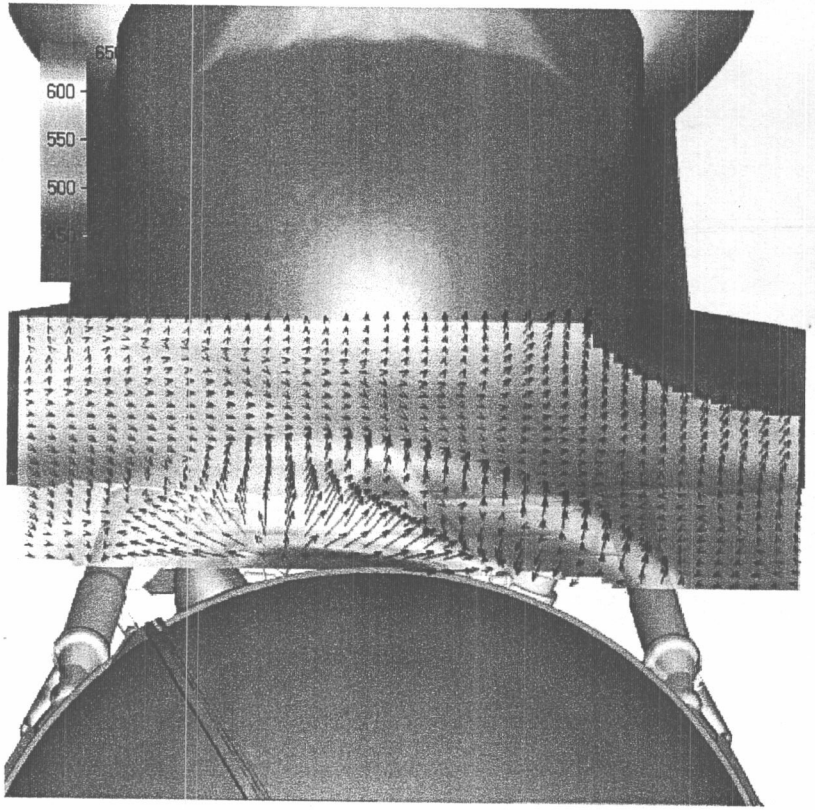
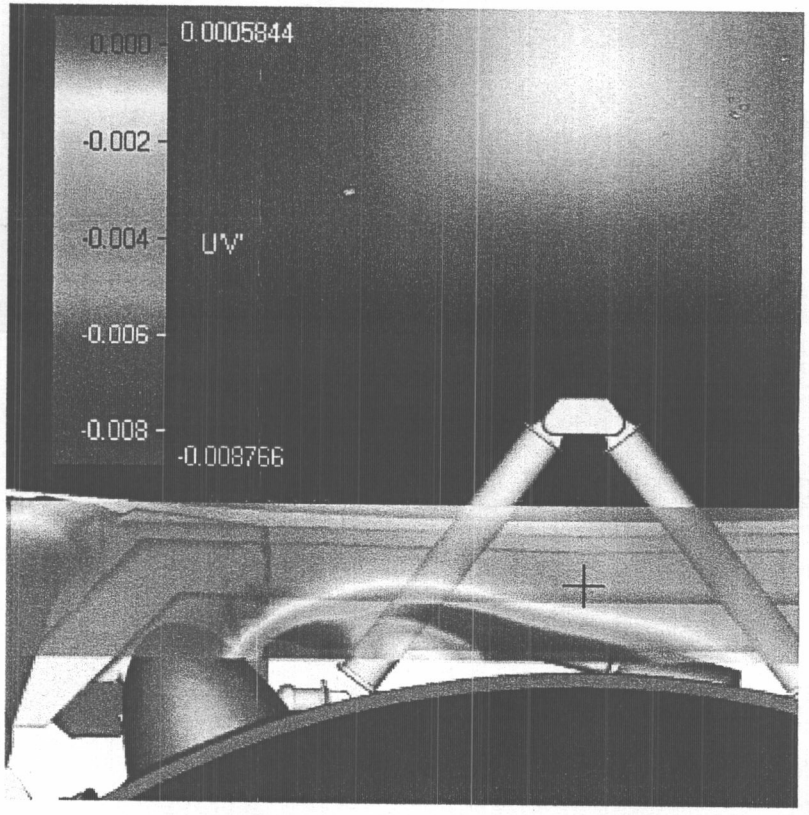
Mach Number = 2.5



Mean axial velocity contours



Reynolds stress in span wise direction